CEMENT AND LIME
MANUFACTURE

PUBLISHED ALTERNATE MONTHS. PRICE 1/- A COPY. ANNUAL SUBSCRIPTION 6s. POST FREE.

PUBLISHED BY
CONCRETE PUBLICATIONS LIMITED
14 DARTMOUTH STREET, LONDON, S.W.1

TELEPHONE: WHITEHALL 4581.
TELEGRAPHIC ADDRESS:
CONCRETIUS, PARL, LONDON.

PUBLISHERS OF
"CONCRETE & CONSTRUCTIONAL ENGINEERING"
"CONCRETE BUILDING & CONCRETE PRODUCTS"
"CEMENT & LIME MANUFACTURE"
"THE CONCRETE YEAR BOOK"
"CONCRETE SERIES" BOOKS, ETC.

VOLUME XVIII. NUMBER 6 NOVEMBER 1945

Cement and Concrete Research in Sweden.

THE Swedish Cement and Concrete Research Institute at the Royal Technical University, Stockholm, was founded in 1941 as the result of the donations of Swedish cement and concrete companies, whose gifts paid for the erection and the equipment of the building as well as its operating expenses for ten years. The Swedish Government enacted the statutes of the Institute and presented a site for its building, and the building was consigned to the State at the inauguration of the Institute in May, 1945. The chairman of the board of the Institute is appointed by the Government, and the members of the board are nominated in equal numbers by the Royal Technical University, Stockholm, and the donors. The chairman of the board is Mr. Sven Schwartz, President of the Swedish Board of Industry.

The purpose of the Institute is to investigate the properties of cement, concrete, and allied materials, and is divided into three sections, namely, the chemical, physics and technical departments. The director of the Institute is Mr. Stig Giertz-Hedström. The head of the physics department is Mr. Erik Forslind, the head of the technical department is Professor Georg Wästlund, and the head of the chemical department is, provisionally, the director of the Institute. The staff totals 25, including four civil engineers, two electrical engineers, two physicists and three chemical engineers.

The building comprises two stories and a basement, with a total volume of 233,000 cu. ft. The basement contains the mixing room, three curing rooms, workshops, a laboratory for rough chemical tests, and an electric power plant. Over the mixing room is the testing hall, extending through the ground and first stories, with a gallery for measurements at first-floor level; the purpose of this arrangement is to isolate the instruments from the testing hall. All the instruments are in the gallery, and the test results are recorded electrically. Contiguous to the testing hall are two freezing rooms provided with temperature control within the range −10 deg. C. to 35 deg. C. A small carpenter's shop is situated near the testing hall. The other rooms on the ground floor are the chemical

laboratory, the administrative department, and rooms for research workers. The first floor accommodates the laboratories of the physics department, which comprise a room for experiments, an optical laboratory, and a small ultra-sound laboratory for the study of properties of materials subjected to the action of the high-frequency vibrations of ultra-sound. These rooms are insulated by metallised floors and walls and metal gratings at the windows so as to prevent external electrical disturbances from affecting measurements and other investigations. A photographic laboratory and rooms for research workers are also situated on the first floor.

The chemical department is at present chiefly occupied with investigations concerning the use of various kinds of slag in the manufacture of cement. The physics department is for the time being chiefly concerned with the elastic properties of concrete subjected to dynamic loads and on the vibration of concrete in which the acceleration and frequency of vibrators and concrete subjected to vibration are studied with the aid of induction-type measuring instruments. The technical department is investigating the cracking of reinforced concrete structures, particularly in connection with concrete landing-tracks, aprons, and other slabs for aerodromes.

The building is itself acting as a concrete test specimen on a large scale, several induction-type pressure gauges having been embedded in the walls and floor slabs by the aid of which the stresses and pressure variations in the concrete can be measured electrically.

In the Spring of 1943 the Institute undertook the courses in concrete engineering formerly conducted by the Government Board of Industry. At the outset the purpose of these courses was the training of inspectors for military construction works, but the programme was extended to include the training of persons intending to devote themselves to general concrete inspection and supervision. More than 1,000 students have so far taken part in these courses, and an advanced course has now been added to the programme.

Recovery of Waste Heat.

THE Ministry of Fuel and Power has issued a bulletin entitled, " The Recovery of Waste Heat from Flue Gases," which will be sent free on application to the Ministry at 2, Little Smith Street, Westminster, S.W.1. The bulletin deals with the methods of ascertaining the quantity of waste heat available and its recovery, furnace operation and management, recuperation and regeneration, waste-heat boilers and their application to specific industries, and the use of economisers with waste-heat boilers.

Refractories in Portland Cement Manufacture.*

By LEOPOLD TSCHIRKY.

Some Features of Kiln Lining Design.

Reference has been made to the special shapes used for discharge end blocks and feed end blocks, but it is well to repeat that these should be simple in design and as small as practicable. Some cement plants might also do well, when faced with the necessity of changing or repairing kiln discharge-ends, to consider the possibilities of doing so in a manner that would permit the use of standard kiln liner shapes right to the end of the kiln.

For the kiln proper, blocks as shown in *Fig.* 16 are accepted as the standard design for fireclay bricks, super-duty fireclay bricks, and high-alumina bricks. In a few instances designs differing from these are used. In such cases the blocks usually differ in either the radial thickness or the thickness which, when installed, is parallel to the kiln axis. At times there may be, and probably are, good reasons to deviate from the standards, but unless this is so it is good practice to confine

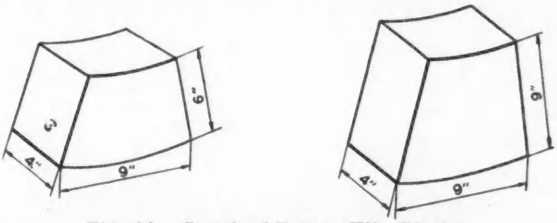


Fig. 16.—Standard Rotary Kiln Blocks.

oneself to standard sizes so far as is possible. As stocks of standard-size blocks are generally carried by the manufacturers, this makes for quicker deliveries for urgent requirements. In some cases it will result in lower first cost of lining not only for the same thickness of lining the special blocks would form, but also, in some cases, for lining of greater thickness than the special blocks will form.

Some plants lay these blocks in rows parallel to the kiln axis. The procedure most usually followed, however, is to lay them so that the blocks in one circle break joint with the blocks in the adjacent circles. From the standpoint of maximum rigidity in the finished linings the latter procedure is preferred.

For basic brick linings the bricks used are arch shapes, as shown in *Fig.* 17. There are very good reasons why the bricks used for basic brick linings are arch shapes. The process employed in the manufacture of basic bricks presents problems differing in some respects from those encountered in the manufacture of fireclay bricks, super-duty fireclay bricks, and high-alumina bricks. These problems make it possible to incorporate the desired characteristics a basic brick must possess to greater degree in such arch shapes. Furthermore, basic bricks are laid in the kiln with a thin metal plate between adjacent bricks. These metal plates serve a very definite function in a basic brick lining and, for all practical purposes, can best do so if laid in the radial joints between arch-shaped bricks

* Concluded from July and September numbers.

rather than in joints falling perpendicular to the kiln axis. The preferred manner of installing basic brick linings is to make up the lining in a series of circles, each circle being independent of the adjacent circles. Whether or not the bricks in one circle break joint with the bricks in the adjacent circles is immaterial. That these linings are made up of straight independent circles, instead of having interlocking bricks that break joint in the horizontal direction, is a practical consideration brought about by the use of metal plates in the radial joints. It would be an extremely difficult task, requiring a great amount of cutting, properly to lay an interlocking basic brick lining in a shell that is not a perfect cylinder. As basic bricks are rarely used until after it has been demonstrated that even high-alumina brick linings are not good enough, it would be rare to find the shell of a kiln that already has had difficulty with other lining materials and is still a perfect cylinder. A further important factor in favour of straight circles is the ease of patching when only a small repair is to be made to the lining.

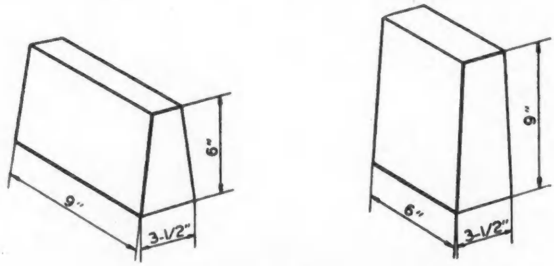


Fig. 17.—Arch-Shape Basic Bricks.

Recently there has been a trend on the part of a few cement plants towards a change from kiln blocks as shown in *Fig.* 16 to arch shapes as shown in *Fig.* 17 for linings of fireclay bricks and high-alumina bricks. While this trend is of recent origin in the United States, the use of arch bricks is not new to the cement industry. The experience of one manufacturer, who has furnished refractories to cement plants in many parts of the world, has been that of the foreign cement plants that changed from arch shapes to the conventional rotary kiln block shape very few changed back to the arch shapes so long as American-made kiln blocks were still available. In the short time the trend has been in progress the reports from users vary considerably. Some seem to be pleased with the change and others have returned to the use of standard rotary kiln blocks (*Fig.* 16).

The question is sometimes asked whether, when arch shapes of fireclay brick or high-alumina brick are used, the lining should be laid in straight circles in the manner followed with basic brick, or if they should be laid in horizontal rows with the bricks in one row breaking joint with those in the adjacent rows. Here theory and practice sometimes clash. Theoretically, it would be desirable to lay the bricks breaking joint in the horizontal direction. If carefully laid, this would be a step in the right direction for maximum rigidity in the lining, and the

interlocking construction could also be expected to offer greater resistance to the tendency of pieces of cracked or spalled brick falling away from the lining. It is not over difficult to lay a tight lining, with bricks breaking joint in the horizontal direction, if the shell is a true cylinder and the arch bricks are uniform in size. But the experiences of some who have done it is that arch bricks so laid have a tendency to crack rather easily in the middle (possibly due to torque). Such cracking finally results in a condition approaching separate circles of about the same horizontal thickness as would be formed had standard kiln blocks been used, but with the disadvantage of having about double the number of pieces in the circle. Realising how very few kiln shells that have seen severe service are perfect cylinders, and the allowable dimensional variations that occur in commercial brick manufacture, and also that well-laid interlocking brickwork has shown a tendency for bricks to crack in the middle, it is the opinion of several that best average results, when arch shapes are used, will be obtained from linings that are tightly laid with the bricks forming individual straight circles.

Regardless of the design of lining or brick shape used, it is important that care be exercised to lay a good tight lining. This is still more important when installing linings in kilns that have bulged shells. It is obvious that bricks made to turn a circle cannot be expected properly to fit a surface that has lost its circular shape unless compensations are provided. This may require cutting or trimming bricks to fit or it may be taken care of by having a few blocks on hand for diameters larger and smaller than the original kiln diameter. Rarely can a circle be closed with a full brick. Too much care cannot be taken properly to cut and fit the key brick. The preferred key brick is one with a chord dimension not less than one-half the chord dimension of a full kiln block. This often requires cutting the key brick, and also one or two of the bricks between which the key brick is to fit. The amount of cutting required can be minimised by having a few bricks on hand that were made with chord dimensions smaller than those of the full brick. Combinations can then be worked out to result in very little cutting or trimming of one brick. These extra bricks are not intended to eliminate all cutting or trimming, but are solely for minimising the amount of cutting that may be necessary. Also, rarely can a length of old lining be replaced with new bricks without some cutting or filling between the last row of new bricks laid and the old work remaining in the kiln. Here, too, it is recommended that bricks be cut to make a tight fit, and this cutting can often be minimised by having " split " kiln blocks made of thicknesses differing from the thickness of the standard blocks. Small cuts, if not too many, can be made with a mason's hammer or with a small pneumatic brick cutting tool, but if many cuts are required a brick-cutting saw is useful.

It is preferable that linings be laid dry, and as short sections are finished, to apply a thin grout to fill any openings that remain between the bricks and between the bricks and the kiln shell. If the lining is properly laid to begin with, little grout will be required. Grout should be used simply to finish the lining and not for the purpose of trying to compensate for deficiencies in the lining procedure.

In some recent installations of new kilns, especially kilns of large diameter,

the initial linings gave longer runs than replacement linings made of the same refractory material. So far as can be ascertained, the only difference in overall conditions was that the initial linings were installed without need to hurry, whereas the replacements were made in the middle of runs. Ordinarily one would expect shorter life on the initial linings due to the many things that can, and usually do, happen that could easily have a damaging effect on linings during the period a new plant settles down to normal operation. The life of the first lining in a new installation is no criterion of future life ; nevertheless, these experiences, coupled with a knowledge that care exercised in lining a kiln is definitely desirable, raise the possibility that some interesting information might be obtained if a record were

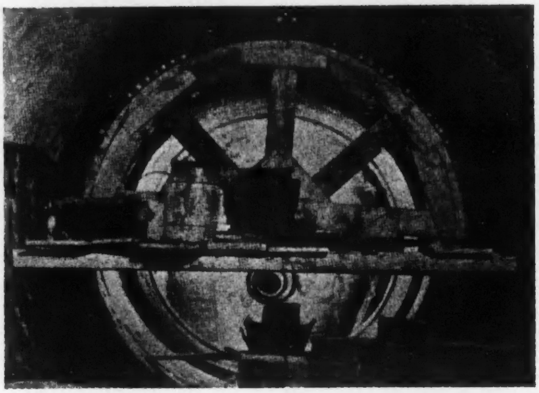


Fig. 18.—The "Arch-Form" Method of Installing Kiln Linings.

kept of the life of linings installed under most favourable conditions compared with the life of linings installed under rush conditions.

Methods of Installing Kiln Linings.

There are three methods of installing linings in a rotary kiln.

The first is the "stick" method, which consists of laying the bottom half of a circle of bricks and propping up with sticks the bricks as they are laid in the upper half of the circle. The key brick is then driven in at the top of the circle. This is not recommended except in very small-diameter kilns where there is not sufficient space to use any other method.

The second is the "arch-form" method, an example of which is shown in *Fig.* 18. This consists of laying sections half-way up the sides of the kiln, after which a built-up form is used around which the upper half of each circle of bricks is laid. As each circle is completed the form is moved ahead to the next circle and the procedure repeated. This method is not often used, although if carefully employed it permits a good installation.

The third and most generally used procedure is the "screw-jack" method. This consists of laying sections in the lower part of the kiln to points above the

kiln axis, then placing reasonably heavy timbers against the top bricks on each side and applying sufficient pressure against these timbers by means of screw-jacks to permit turning the kiln without any chance of slipping or collapsing of the section of brickwork that is jacked. *Fig.* 19 illustrates a lining with jacks in place. The jacks are made of metal pipes provided at one or both ends with a screw-jack. For kilns 8ft. in diameter or under one screw-jack is sufficient on each jack. For larger-diameter kilns it is preferable to have a screw-jack at each end of the jack. Also, when a screw-jack is placed on each end, it is desirable to have one with a right-hand thread and the other with a left-hand thread so that in tightening or loosening the jack the pipe itself is turned and in so doing the two ends either expand or contract. Such double-ended jacks can be tightened or loosened by means of a large Stillson wrench. Better still is to have the jack-pipe so heavy that holes can be drilled through it at right angles at about the

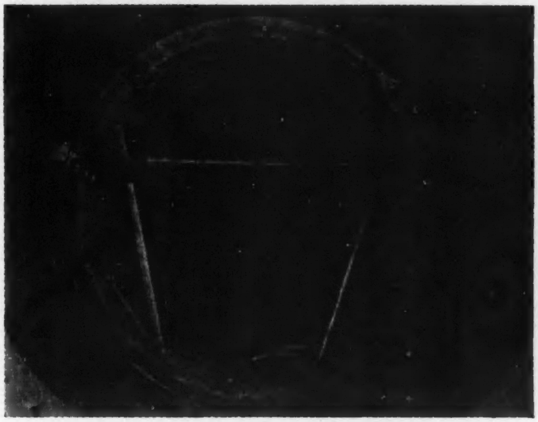


Fig. 19.—The "Screw-Jack" Method of Installing Kiln Linings.

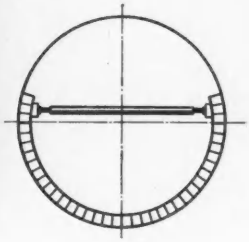


Fig. 20.

centre into which a heavy bar can be inserted to use for turning. The proper jacking of a lining is important. It is desirable to build the jacks so that the pipes, thread-bushing and screws are all in one piece; also to provide the ends with bearing plates so attached that they can rest firmly against the timbers. Sufficient bricks should be laid so that the jacks when first installed will be above the axis of the kiln, as illustrated in *Fig.* 20. Laying 56 per cent. or 57 per cent. of the circle will be found satisfactory. This will leave the inner faces of the top bricks in planes that are not at right-angles to the direction of the pressure exerted by the jacks. It is important that provision be made to compensate for this, or the tendency will be for the bricks under the jack timbers to raise and cause an opening in the joints between these bricks and those under them. An excellent and positive way of preventing this is to use jack-timbers that are cut to proper taper.

Variable Kiln-Lining Life.

Even though a wise choice of refractory has been made, and every care taken properly to install it, how can one account for the variable results that often occur ? And is there anything that can be done about it ? The answer is that no two runs, whether on the same kiln or not, are under identical operating conditions. There is much that occurs in a kiln that can, and does, have a very definite effect on the life of the refractory. We have seen the effect on the life of a lining of changing conditions of fuel and combustion, variation in load material in volume and analysis, intermittent service versus steady runs, and numerous other items, not the least of which is the human element. If all of these could be co-ordinated into a balance that produced maximum lining life, and if that balance could be maintained day in and day out, then most of the present variables in the life of refractories would disappear.

Linings for Kiln Hoods and Other Auxiliary Equipment.

In kiln hoods, especially those that are tightly sealed in the kiln, the problem frequently resolves itself into the design of the hood as much as of the refractories. Fusion, slagging, and spalling are the principal causes of failure in kiln hoods and much that has already been said on these subjects applies to the refractories problems encountered in kiln hoods. In addition to features of design that involve the inner face, top and sides of the kiln hood as related to the kiln itself, attention should be given to the thickness of the lining. Dependent on the grade of refractory used and the temperature it will be subjected to, there is a limit to kiln hood lining thickness beyond which additional thickness is ineffective. This is illustrated by the experience at a plant where kiln hoods built of first-quality fireclay bricks fused, or slagged away, so rapidly that excessive repairs were necessary in less than three months. In an effort to improve this the thickness of the lining was gradually increased until it reached 40 in. in the lower half and 31 in. at the top. However, as the thickness increased the insulating effect also increased, with the result that the life did not improve—in fact, at times, it was less than before. The increased insulating effect of the thicker lining, plus clinker dust in the presence of the hot face of the lining at high temperature, caused rapid fusion until the lining became thin enough to benefit by the cooling effect from the outer face. Finally, 13½ in. linings were installed and the life increased immediately. The subject of fusion and slagging effect of clinker applies to refractories for kiln hood lining in much the same manner as in the burning zone lining. This accounts for the satisfactory results some plants obtain from kiln hoods of high-alumina bricks.

The bonding material for bricks in kiln hoods (and frequently in other linings) also deserves attention. Depending upon the severity of service expected the bricks are usually laid in either fireclay or refractory cement. A kiln hood where the bricks were laid with a good grade of refractory cement, after being in service for two years required no repairs whatsoever, whereas, prior to using refractory cement, it was common in this plant to rebuild kiln hoods once a year.

Temperatures in rotary clinker coolers are not high enough to cause fusion or slagging, and the problem resolves itself chiefly into one of choosing refractories of high abrasion resistance with a high resistance to spalling. In recent years much attention has been given to the subject of quickly cooling clinker, and to start the cooling while the clinker is still at almost maximum temperature. This has been accompanied by the introduction of cooling equipment of different types, such as the preheater, air-quenching, and recuperator type, etc. Most of these require that temperatures at the discharge end of the kiln, in the clinker chutes, and in the high-temperature zone of the equipment itself be higher than was formerly carried in these relative positions.

Observations.

It is always good practice to bring a refractory lining to operating temperature slowly and gradually. This is more important with newly laid linings and old linings that have stood idle long enough to have absorbed considerable moisture from the atmosphere than is the case with linings that have seen service and have been idle for a relatively short time. A few extra hours added to the heating-up period usually adds many hours to the life of the lining.

If bricks are stored where they are exposed to water absorption, they will absorb a considerable amount of water. A water-soaked brick, if not dried out before subjecting it to high heat, can act very much like a tightly corked bottle of water placed on a hot stove. In the case of the brick there is no cork to blow out.

Rush repair jobs must, of course, be done in the shortest possible time, but frequently an item which in itself appears to be time-consuming can easily speed up other items of installation to the end that a saving is effected in overall installation time. It can also result in a better installation. There should be little occasion to throw and pile bricks at random into a kiln. It is far better policy to try to preserve as much as possible the sharp corners and edges which the manufacturers go to great trouble to give to the bricks.

A large-diameter kiln is easier to line than a small one. However, fully to take advantage of this condition there are some aids that can easily be supplied to give assurance of speed and good workmanship. To lay bricks on the sides of a large kiln can be done quicker and better from a few planks properly placed than it is if attempted from an insecure footing. The planks are also helpful when the time comes to jack the lining, as well as for fitting and driving key bricks to close circles.

Occasionally linings are installed in kilns in need of mechanical repair to such a degree that no refractory can do its best. Linings have been installed in kilns with so many loose rivets (many out altogether) at butt-straps, or in tire zones, that when the kiln revolved the movement between adjacent shell plates loosened the lining and contributed to much shorter life of the lining than if the rivets were all in place and tight. Linings have also been placed in kilns with badly cracked shells at the front tire, with the result there was bound to be deflection

as the kiln revolved. The effect on the lining is obvious. Linings have been laid in kilns with the shell burned out in spots. Linings have also been laid in shells that resembled more the extended bellows of an accordion than a rotary kiln. In all such installations the linings are at a decided disadvantage from the start. Extensive kiln repairs cannot be conveniently made in the midst of a run, but it is surprising how often one encounters kiln conditions as described when a lining is being installed in a kiln that has been idle for some weeks. Very often, because pressed for production or a desire to economise, when a repair must be made during the course of a run there is a temptation to replace too small a section of lining and leave some lining in the kiln that has the appearance of being able to render further service. Occasionally it may work surprisingly well, but usually it does not and the kiln must be stopped again for a repair that should have been made when the kiln was stopped before.

Some years ago badly flared and burned-out coal-burner pipes were a very common cause of shortening the life of the lining in the burning zone. Paradoxical as it may seem, the trend towards higher temperatures at the discharge end of kilns has reduced materially damage to linings from this cause. The higher temperatures caused burner pipes to flare and burn out to such an extent that some way had to be found to improve burner-pipe service. This has come about in several ways, including water cooling, the use of heat-resisting metal, and in some cases by making the burner pipe of the thinest practicable thickness to benefit by the cooling effect of the primary air fed through the pipe with the coal.

Occasionally kilns have a heavy accumulation of dust caked on the outer shell. In one plant it was found that burning zone lining life was sufficiently greater when the kilns operated without this layer of dust that it became standard practice to sweep the kilns with stiff wire brooms at fixed intervals.

[On page 74 of the July number, one line was printed twice and one line omitted. The beginning of the second paragraph should read: "The first approach to increased density is the size of the grains constituting the batch. Refractories are now available in which high density is achieved by screening . . ." The first sentence of paragraph 4 on page 79 should read: "Refractory service conditions are generally most severe, and lining replacements most extensive, in the burning zone or calcining zone."

This article is an abstract of a paper presented to the last annual general meeting of the Technical Committees of the American Portland Cement Association.]

The Cement Industry in Mexico.

In our July number we gave some notes on the cement industry in Mexico, and some illustrations of new cement works and extensions. For these notes and photographs we were indebted to Sr. Ingeniero Frederico Barona, of the Schemes Department of the National Irrigation Commission of Mexico.

The Nephelometric Determination of Sulphuric Anhydride in Cements.*

By LÉON BLONDIAU.

(DIRECTOR OF THE S. A. DES CIMENTS DE THIEU.)

Differences Arising from the Graduated Tube.

It would be as well to see whether the substitution of the graduated tube could make any serious difference in determining the height of the suspension, owing to differences in the refraction of light by the base of the tube. For this purpose, the results obtained with ten different tubes were compared with those obtained with the tube used for all the determinations discussed in the present study and which is called the datum tube. These results showed that, provided tubes having a well polished end are used, differences arising from its replacement do not exceed the figure of a reading error. The maximum error ascertained for a 2·2 per cent. SO_3 content was, in fact, 2 mm. with a difference in SO_3 of 0·04 per cent.

TABLE IX.

INFLUENCE OF DELAY BETWEEN COOLING AND PREPARING SUSPENSION

DELAY IN PREPARING SUSPENSION (HOURS & MINUTES)	AVERAGE HEIGHTS IN MM OF 3 TESTS	AVERAGE DEVIATIONS IN MM	SO^3%	DEVIATIONS IN SO^3 BETWEEN DELAY O AND DELAY T
0·00	66·5	0·3	2·11	-
0·30	67·0	0·0	2·10	0·01
1·00	66·3	0·4	2·11	0·00
2·00	66·0	0·3	2·12	0·02
4·00	65·8	0·4	2·12	0·02
8·00	66·5	0·3	2·11	0·01
24·00	66·2	0·3	2·12	0·02
48 00	66·5	0·0	2·11	0·01

Influence of Delay in Preparing the Suspension.

Any delay in the preparation of the suspension is contrary to the principal object of the method, which is to obtain results in the shortest possible time. But as treatment was being carried out on a solution containing soluble silicic acid it was thought desirable to examine the possible errors due to delay in preparing the suspension; this means the time lost between cooling and the preparation of the $BaSO_4$ suspension. Three samples of 0·5 gr. of cement with a known SO_3 content (2·10 per cent.) were placed in a hydrochloric acid solution as described, and the filtrate, after being collected in a 100-ccm. vessel, was cooled in a stream of cold water. After cooling to 20 deg. C., the suspension was prepared; the results of this test are shown in *Table IX* under "zero delay." For other tests made under identical conditions, the delays in the preparation of the suspension were 30 minutes, 1 hour, 2 hours, 4 hours, 8 hours, 24 hours, and 48 hours—all reckoned from this "zero delay." The results are shown in *Table IX*. If a deviation of 1 mm. is admitted as a limit, a deviation which,

* Continued from September number.

as we shall see later, entails an error of 0·02 per cent. SO_3 for the 2·10 per cent. content being examined, the results of tests delayed by as much as 48 hours show that this delay has no effect exceeding the 1-mm. limit.

Operational Method.

To determine the SO_3 content of a cement, weigh out exactly 5 gr., place it in a 50 ccm. porcelain vessel, add 10 ccm. water, then 5 ccm. concentrated HCl (density 1·195). Solution will be aided by crushing the cement with a flat-ended stirrer. Boil, pour into a quick-acting filter, collect the filtrate in a 100-ccm. vessel graduated at 20 deg. C., wash with a little warm water up to the mark, and place under a cold-water tap to bring the temperature to 20 deg. C. Readjust to the mark and homogenise the solution.

(*a*) For Portland and metallic cements, whose SO_3 contents usually lie between 1·5 per cent. and 3 per cent., the contents of the 100-ccm. vessel are placed in a 150-ccm. beaker.

(*b*) For hypersulphated normal metallic cements, whose SO_3 content varies between 5 per cent. and 6 per cent., 50 ccm. of the solution are removed, 2·5 ccm. HCl (density 1·195) are added, and the whole is diluted up to 100 ccm. and transferred to a 250-ccm. beaker.

(*c*) For high-resistance hypersulphated metallic cements, containing between 7 per cent. and 10 per cent. SO_3, 25 ccm. of the solution are removed, 3·75 ccm. HCl (density 1·195) are added, the whole is diluted to 100 ccm., and transferred to a 250 ccm. beaker.

Readings can thus be taken in the part of the curve corresponding, for slight SO_3 differences, to the greatest heights of suspension. Add 0·5 gr. $BaCl_2$, 2 aq., *in crystals whose dimensions come between Tyler sieves Nos. 48 and 28, i.e., mesh* openings of 1·17 and 0·589 mm. Stir slowly at the rate of one rotation per second for 60 seconds so as to facilitate the solution of the $BaCl_2$ and the formation of a finely divided barium sulphate suspension.

Having adjusted the luminous intensity and stopped stirring, the suspension is poured into the graduated tube of the nephelometer, at first slowly until the luminous disc is attenuated and then drop by drop until the luminous filament has completely disappeared when viewed from every angle. This operation should be carried out within 30 seconds of ceasing to stir. The operation is easier if it is conducted in a dark room, or in the dimmest part of the laboratory. Care must be taken to wipe well the bottom of the tube to prevent mist caused by the heat of the lamp from obscuring the luminous disc. It is advisable to wipe the end of the tube with a little glycerine. Turn off the lamp between two determinations to prevent the apparatus becoming overheated. The height of the liquid in the tube is read by taking the lower meniscus as datum.

The SO_3 content as a function of the height of suspension is given by the reference diagram (*Fig.* 6). Using a cement selected as standard whose SO_3 content is exactly known from a number of gravimetric tests, various quantities of cement are weighed out so as to have a number of standards. With a cement whose SO_3 content was evaluated gravimetrically at 2·22 per cent., the results

in *Table X* were obtained. These results enabled the experimental curve to be drawn, in tracing which the following absolute measurements were used: 1 per cent. SO_3 concentration, 200 mm.; 1 mm. height of suspension, 3 mm. This curve is a hyperbola with the equation

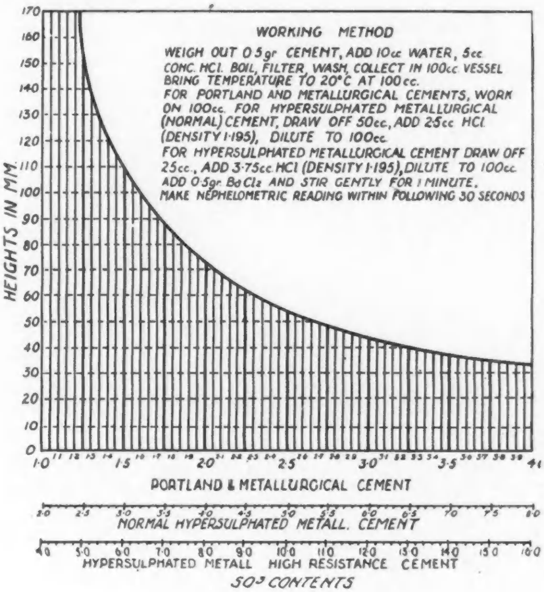


Fig. 6.

TABLE X.

WEIGHT OF CEMENT AT 2·22% OF SO_3 (gr.)	CORRESPONDING % OF SO_3	HEIGHTS OF SUSPENSION DETERMINING DISAPPEARANCE OF FILAMENT (mm)
0·225	1·00	170
0·270	1·20	170
0·288	1·28	141
0·337	1·50	105
0·450	2·00	72
0·563	2·50	52
0·675	3·00	44
0·788	3·50	36
0·900	4·00	32

$$f(xy) = x^2 - 234{,}777\,xy + 36{,}536\,y^2 - 21{,}906\,x - 234{,}930\,y + 485{,}574 = 0,$$

the unit of measurement in obtaining the equation of the curve being the length of 1 per cent. SO_3 concentration (1 per cent. concentration, 0 mm. height). The characteristics of this hyperbola are as follows: The centre corresponds to $-0{\cdot}032$ per cent. concentration and $-6{\cdot}8$ mm. height and the asymptotes

incline towards the axis of concentrations of $_1 = 81° 9'$ and $\alpha_{2_2} = 0° 15'$. The minimum deviations of the theoretical curve on each of the axes correspond respectively to the points on the co-ordinates: (1) With the axis of concentrations (ox): 22·52 per cent. concentration and 6 mm. height; (2) With the axis of heights (oy): 1·13 per cent. concentration and 242 mm. height.

It appears that the method, in the form applied to Portland cements, is theoretically inapplicable to concentrations below 1·13 per cent. SO_3, and as soon as the SO_3 content is less than 1·20 per cent. SO_3, given the same capacity and

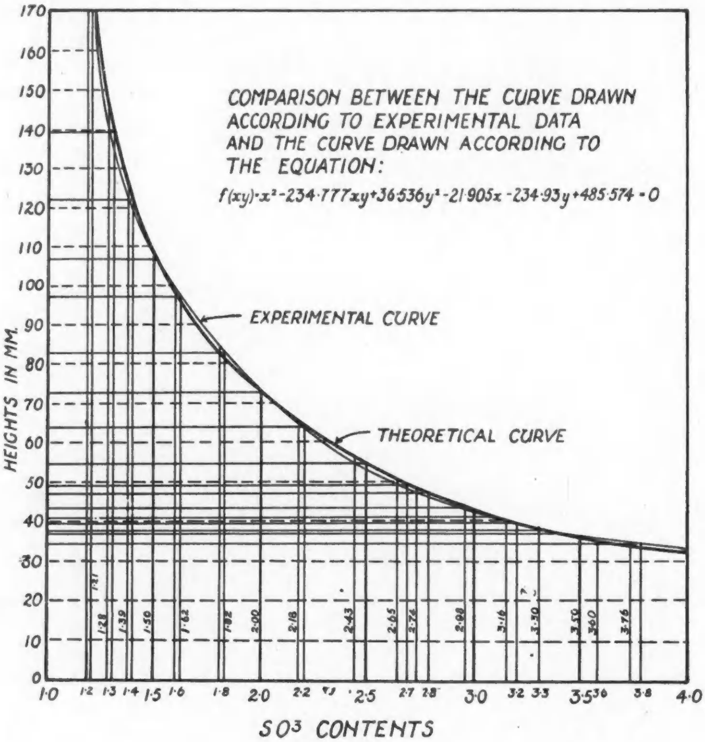


Fig. 7.

graduation of the observation tube. For concentrations above 4 per cent. the degree of accuracy in the form applied to Portland cements is insufficient for practical applications, although in theory the method permits of measurements of 22·52 per cent. SO_3. The almost perfect coincidence of the curve drawn from experimental work and the curve calculated from the equation deduced from the same results (*Fig.* 7) testifies to the accuracy of the reference curve. *Table XI* is the reference table. An examination of the experimental curve also makes it possible to determine the differences in SO_3 content due to an error of reading

of 1 mm., the normal limit of tolerance of the height of the suspension. A later table gives the deviations in SO_3 corresponding to a height of suspension of 1 mm. for various values of SO_3.

Since the estimate of the SO_3 content in Portland and blast-furnace cements is made by direct reading with 100 ccm. of filtrate, it is evident from the table that it is possible to use the nephelometric method successfully with all Portland

TABLE XI.

NEPHELOMETRIC DETERMINATION OF SULPHURIC ANHYDRIDE IN CEMENTS. REFERENCE TABLE.

HEIGHT OF SUSP. IN MM.	SO3 CONTENTS			HEIGHT OF SUSP. IN MM.	SO3 CONTENTS			HEIGHT OF SUSP. IN MM.	SO3 CONTENTS			HEIGHT OF SUSP. IN MM.	SO3 CONTENTS		
	NORM. ARTI. PORTLAND C. NORM. METALL. CEMENT	NORMAL HYPERSUL. METALL. CEMENT	HYPERSUL. METALL. HIGH RESIST. CEMENT		NORM. ARTI. PORTLAND C. NORM. METALL. CEMENT	NORMAL HYPERSUL. METALL. CEMENT	HYPERSUL. METALL. HIGH RESIST. CEMENT		NORM. ARTI. PORTLAND C. NORM. METALL. CEMENT	NORMAL HYPERSUL. METALL. CEMENT	HYPERSUL. METALL. HIGH RESIST. CEMENT		NORM. ARTI. PORTLAND C. NORM. METALL. CEMENT	NORMAL HYPERSUL. METALL. CEMENT	HYPERSUL. METALL. HIGH RESIST. CEMENT
32	3·97	7·94	15·88	67	2·10	4·20	8·40	102	1·56	3·12	6·24	137	1·29	2·58	5·16
33	3·83	7·66	15·32	68	2·08	4·16	8·32	103	1·55	3·10	6·20	138	1·29	2·58	5·16
34	3·72	7·44	14·88	69	2·06	4·12	8·24	104	1·54	3·08	6·16	139	1·28	2·56	5·12
35	3·63	7·26	14·52	70	2·04	4·08	8·16	105	1·53	3·06	6·12	140	1·28	2·56	5·12
36	3·52	7·04	14·08	71	2·02	4·04	8·08	106	1·52	3·04	6·08	141	1·28	2·56	5·12
37	3·44	6·88	13·76	72	2·00	4·00	8·00	107	1·51	3·02	6·04	142	1·27	2·54	5·08
38	3·37	6·74	13·48	73	1·98	3·96	7·92	108	1·50	3·00	6·00	143	1·27	2·54	5·08
39	3·30	6·60	13·20	74	1·96	3·92	7·84	109	1·49	2·98	5·96	144	1·27	2·54	5·08
40	3·23	6·46	12·92	75	1·94	3·88	7·76	110	1·48	2·96	5·92	145	1·26	2·52	5·04
41	3·17	6·34	12·68	76	1·92	3·84	7·68	111	1·47	2·94	5·88	146	1·26	2·52	5·04
42	3·10	6·20	12·40	77	1·90	3·80	7·60	112	1·46	2·92	5·84	147	1·26	2·52	5·04
43	3·03	6·06	12·12	78	1·88	3·76	7·52	113	1·45	2·90	5·80	148	1·25	2·50	5·00
44	2·97	5·94	11·88	79	1·87	3·74	7·48	114	1·44	2·88	5·76	149	1·25	2·50	5·00
45	2·91	5·82	11·64	80	1·86	3·72	7·44	115	1·43	2·86	5·72	150	1·25	2·50	5·00
46	2·84	5·68	11·36	81	1·84	3·68	7·36	116	1·42	2·84	5·68	151	1·25	2·50	5·00
47	2·78	5·56	11·12	82	1·82	3·64	7·28	117	1·42	2·84	5·68	152	1·25	2·50	5·00
48	2·72	5·44	10·88	83	1·81	3·62	7·24	118	1·41	2·82	5·64	153	1·25	2·50	5·00
49	2·66	5·32	10·64	84	1·79	3·58	7·16	119	1·40	2·80	5·60	154	1·24	2·48	4·96
50	2·60	5·20	10·40	85	1·78	3·56	7·12	120	1·39	2·78	5·56	155	1·24	2·48	4·96
51	2·56	5·12	10·24	86	1·76	3·52	7·04	121	1·38	2·76	5·52	156	1·24	2·48	4·96
52	2·52	5·04	10·08	87	1·75	3·50	7·00	122	1·37	2·74	5·48	157	1·24	2·48	4·96
53	2·47	4·94	9·88	88	1·73	3·46	6·92	123	1·36	2·72	5·44	158	1·23	2·46	4·92
54	2·44	4·88	9·76	89	1·72	3·44	6·88	124	1·36	2·72	5·44	159	1·23	2·46	4·92
55	2·41	4·82	9·64	90	1·71	3·42	6·84	125	1·35	2·70	5·40	160	1·23	2·46	4·92
56	2·38	4·76	9·52	91	1·69	3·38	6·76	126	1·35	2·70	5·40	161	1·23	2·46	4·92
57	2·35	4·70	9·40	92	1·68	3·36	6·72	127	1·34	2·68	5·36	162	1·23	2·46	4·92
58	2·32	4·64	9·28	93	1·67	3·34	6·68	128	1·34	2·68	5·36	163	1·22	2·44	4·88
59	2·29	4·58	9·16	94	1·65	3·30	6·60	129	1·33	2·66	5·32	164	1·22	2·44	4·88
60	2·26	4·52	9·04	95	1·64	3·28	6·56	130	1·33	2·66	5·32	165	1·22	2·44	4·88
61	2·24	4·48	8·96	96	1·63	3·26	6·52	131	1·32	2·64	5·28	166	1·22	2·44	4·88
62	2·21	4·42	8·84	97	1·62	3·24	6·48	132	1·31	2·62	5·24	167	1·22	2·44	4·88
63	2·19	4·38	8·76	98	1·60	3·20	6·40	133	1·31	2·62	5·24	168	1·21	2·42	4·84
64	2·17	4·34	8·68	99	1·59	3·18	6·36	134	1·30	2·60	5·20	169	1·21	2·42	4·84
65	2·15	4·30	8·60	100	1·58	3·16	6·32	135	1·30	2·60	5·20	170	1·21	2·42	4·84
66	2·12	4·24	8·48	101	1·57	3·14	6·28	136	1·30	2·60	5·20				

and metallurgical cements (*Table XII*), their maximum SO_3 content being fixed at 3 per cent. and the possible error of method for 1 mm. of height of suspension for this same value of 3 per cent. being only 0·06 per cent. according to the experimental curve. For the normal hypersulphated cements whose SO_3 content practically lies between 5 per cent. and 6 per cent., as the nephelometric treatment only uses half of the 100 ccm. filtrate, the possible error in method is

TABLE XII.

A HEIGHT OF SUSPENSION OF 1MM. CORRESPONDS	
FOR SO^3 VALUES BETWEEN	% SO^3
1·20 AND 1·36	LESS THAN 0·010
1·36 " 1·60	UP TO 0·010
1·60 " 1·90	" 0·015
1·90 " 2·19	" 0·020
2·19 " 2·29	" 0·025
2·29 " 2·44	" 0·030
2·44 " 2·60	" 0·040
2·60 " 3·03	" 0·060
3·03 " 3·44	" 0·070
3·44 " 3·52	" 0·080
3·52 " 3·72	" 0·090
3·72 " 3·83	" 0·110
3·83 " 3·97	" 0·140

double that allowed for in the case of the Portland cements and varies, for a difference of 1 mm. in the height of suspension, from 0·08 to 0·12 per cent. Finally, in the case of metallurgical cements of the hypersulphated high-resistance type, whose SO_3 content lies practically between 7·5 per cent. and 8·5 per cent., where one-quarter of the filtrate only is used, the possible error in method is between 0·08 per cent. and 0·10 per cent. for a difference of 1 mm. in the height of suspension. From all these considerations we may conclude that the calculated curve according to the equation may also be used as a reference curve.

Application of the Method: Results of Tests.

The final application of the method was in each case preceded by two series of tests: (1) The determination of the SO_3 content of each of the cements investigated by 20 gravimetric tests. Three operators also carried out 20 nephelometric tests on the same cements. All these tests confirmed the reference curve. (2) The determination of SO_3 in 50 cements of each type according to gravimetric and nephelometric methods. The object of the latter was to verify the conclusions drawn from the former series; this seemed of importance since the results of the first series favoured the adoption of the nephelometric method.

The average of the results obtained gravimetrically represents the exact SO_3 content. However, a comparison of average results is, by itself, inadequate to establish the value of a method. It is not enough for the average results to agree; individual results must also show perfect regularity. This quality of a method is evaluated by the deviations, either average, quadratic, or even maximum, according to the needs of the practical application. It must be borne in mind that under practical conditions a single check test is generally carried out. In exceptional cases two or at most three tests are effected to ensure a SO_3 content with the maximum accuracy.

As regards maximum SO_3 content, specifications place Portland and blast-furnace cements on the same footing; moreover they generally contain identical amounts of calcium sulphate. Nevertheless, the latter type of cement was made the subject of separate tests, the results of which are interpreted with the others.

The average results of twenty different determinations are shown in the *Tables XIII* and *XIV*; they testify to the accuracy and regularity of the nephelometric method by comparison with the gravimetric method. From this series of tests it is concluded that: (1) The average nephelometric results are identical with the gravimetric results, thus suggesting equal accuracy; the average differences between the results of the two methods were confined to a maximum

TABLE XIII.

RESULTS OF 1ST. SERIES OF TESTS ON ARTIFICIAL PORTLAND CEMENT

	1·51% SO_3				1·93% SO_3				2·53% SO_3				3·34% SO_3			
	SO_3 according to Belgian gravimetric method	SO_3 according to nephelometric method operator			SO_3 according to Belgian gravimetric method	SO_3 according to nephelometric method operator			SO_3 according to Belgian gravimetric method	SO_3 according to nephelometric method operator			SO_3 according to Belgian gravimetric method	SO_3 according to nephelometric method operator		
		A	B	C		A	B	C		A	B	C		A	B	C
AVERAGE	1·51	1·49	1·52	1·52	1·93	1·90	1·96	1·96	2·53	2·47	2·56	2·51	3·34	3·32	3·30	3·35
AVERAGE DEVIATIONS	0·042	0·013	0·017	0·017	0·034	0·031	0·012	0·018	0·031	0·009	0·018	0·020	0·030	0·022	0·039	0·029
MAXIMUM DEVIATIONS	0·15	0·05	0·05	0·06	0·11	0·12	0·05	0·08	0·14	0·06	0·10	0·08	0·11	0·05	0·09	0·10
QUADRATIC DEVIATIONS	0·048	0·014	0·019	0·019	0·038	0·035	0·014	0·021	0·037	0·016	0·022	0·028	0·034	0·022	0·041	0·035
RELATIVE AVERAGE D	2·78%	0·87%	1·13%	1·12%	1·74%	1·63%	0·01%	0·92%	1·22%	0·36%	0·70%	0·80%	0·90%	0·65%	1·18%	0·86%

TABLE XIV.

RESULTS OF 1ST. SERIES OF TESTS ON BLAST FURNACE CEMENT

	1·28% SO_3				1·97% SO_3				3·00% SO_3			
	SO_3 according to Belgian gravimetric method	SO_3 according to nephelometric method operator			SO_3 according to Belgian gravimetric method	SO_3 according to nephelometric method operator			SO_3 according to Belgian gravimetric method	SO_3 according to nephelometric method operator		
		A	B	C		A	B	C		A	B	C
AVERAGE	1·28	1·25	1·27	1·28	1·97	1·92	1·94	1·94	3·00	3·00	2·95	3·03
AVERAGE DEVIATIONS	0·025	0·001	0·037	0·020	0·026	0·020	0·011	0·009	0·023	0·057	0·032	0·050
MAXIMUM DEVIATIONS	0·09	0·02	0·07	0·03	0·10	0·07	0·04	0·03	0·12	0·16	0·10	0·13
QUADRATIC DEVIATIONS	0·028	0·003	0·043	0·0207	0·031	0·024	0·016	0·012	0·029	0·060	0·036	0·055
RELATIVE AVERAGE D	1·95%	0·08%	2·91%	1·56%	1·32%	1·04%	0·57%	0·46%	0·77%	1·90%	1·08%	1·65%

of 0·06 per cent. SO_3 of the gravimteric method, i.e. a relative difference of 2·54 per cent. of the value of this result. (2) The amount of deviation remains within the limits provided for by the curve and establishes the regularity of the results; as a rule, the amount of this deviation is less in the nephelometric method than in the gravimetric method; this regularity is inherent in the simplicity and rapidity of the former method.

Allowance must be made for the human factor of personal estimates, the sight of one operator differing from that of another; this is responsible for the slight deviations noticed in the results of the different operators. These deviations reached a maximum of 0·09 per cent. in the case of Portland cement and 0·08 per cent. in the case of blast-furnace cement, or 3·5 per cent. and 2·6 per cent. respectively of the amount measured.

TABLE XV.

EXTRACT OF RESULTS OF 2ND SERIES OF TESTS ON ARTIFICIAL PORTLAND CEMENT

No OF SAMPLES	BELGIAN GRAVIMETRIC METHOD				NEPHELOMETRIC METHOD				COMPARISON OF 2 METHODS		
	AVERAGE RESULTS	MAXIMUM DEVIATIONS	ABSOLUTE AVERAGE DEVIATIONS	RELATIVE AVERAGE DEVIATIONS	AVERAGE RESULTS	MAXIMUM DEVIATIONS	ABSOLUTE AVERAGE DEVIATIONS	RELATIVE AVERAGE DEVIATIONS	MAXIMUM DEVIATIONS	ABSOLUTE AVERAGE DEVIATIONS	RELATIVE AVERAGE DEVIATIONS
5	1·30	0·01	0·00	0·00	1·34	0·02	0·01	0·74	0·06	0·04	3·08
10	1·62	0·10	0·05	3·09	1·62	0·04	0·02	1·23	0·08	0·00	0·00
15	1·73	0·06	0·02	1·15	1·75	0·05	0·02	1·14	0·07	0·02	1·15
20	1·82	0·05	0·03	1·65	1·84	0·05	0·02	1·08	0·08	0·02	1·10
25	1·89	0·06	0·02	1·05	1·89	0·03	0·01	0·52	0·05	0·00	0·00
30	1·96	0·07	0·04	2·04	1·98	0·05	0·02	1·01	0·07	0·02	1·02
35	2·12	0·06	0·02	0·94	2·08	0·05	0·02	0·98	0·10	0·04	1·88
40	2·40	0·01	0·00	0·00	2·37	0·04	0·02	0·84	0·07	0·03	1·25
45	2·68	0·06	0·02	0·75	2·66	0·05	0·02	0·75	0·07	0·02	0·75
50	3·35	0·09	0·03	0·89	3·33	0·10	0·04	1·20	0·10	0·02	0·60

TABLE XVI.

EXTRACT OF RESULTS OF 2ND SERIES OF TESTS ON BLAST FURNACE CEMENT

No OF SAMPLES	BELGIAN GRAVIMETRIC METHOD				NEPHELOMETRIC METHOD				COMPARISON OF 2 METHODS		
	AVERAGE RESULTS	MAXIMUM DEVIATIONS	ABSOLUTE AVERAGE DEVIATIONS	RELATIVE AVERAGE DEVIATIONS	AVERAGE RESULTS	MAXIMUM DEVIATIONS	ABSOLUTE AVERAGE DEVIATIONS	RELATIVE AVERAGE DEVIATIONS	MAXIMUM DEVIATION	ABSOLUTE AVERAGE DEVIATIONS	RELATIVE AVERAGE DEVIATIONS
5	1·52	0·08	0·03	1·97	1·54	0·05	0·02	1·30	0·09	0·02	1·32
10	1·67	0·08	0·03	1·79	1·63	0·04	0·02	1·22	0·08	0·04	2·39
15	1·86	0·05	0·02	1·07	1·84	0·02	0·01	0·54	0·05	0·02	1·07
20	2·07	0·06	0·03	1·45	2·02	0·02	0·01	0·49	0·09	0·05	2·41
25	2·14	0·03	0·01	0·47	2·16	0·06	0·02	0·93	0·07	0·02	0·96
30	2·30	0·00	0·00	0·00	2·29	0·04	0·02	0·87	0·02	0·01	0·43
35	2·45	0·01	0·01	0·41	2·43	0·04	0·02	0·82	0·04	0·02	0·81
40	2·53	0·04	0·02	0·79	2·53	0·02	0·01	0·39	0·03	0·00	0·00
45	2·87	0·05	0·02	0·69	2·85	0·03	0·01	0·35	0·05	0·02	0·70
50	3·33	0·00	0·00	0·00	3·30	0·00	0·00	0·00	0·03	0·03	0·90

The second series of tests (*Tables XV* and *XVI*) may be regarded as a first practical application. Nevertheless, with the object of again checking the accuracy and regularity of the method for the different SO_3 contents met with in manufacture, viz., from 1·2 per cent. to 3·3 per cent., tests were made in triplicate. Ten results in each case were as follows. Average deviations: Portland cement, 0·12 per cent.; metallurgical blast-furnace cement, 0·07 per cent. Average deviations expressed as a percentage of the gravimetric result: Portland cement, 4·86 per cent.; metallurgical blast-furnace cement, 2·79 per cent.

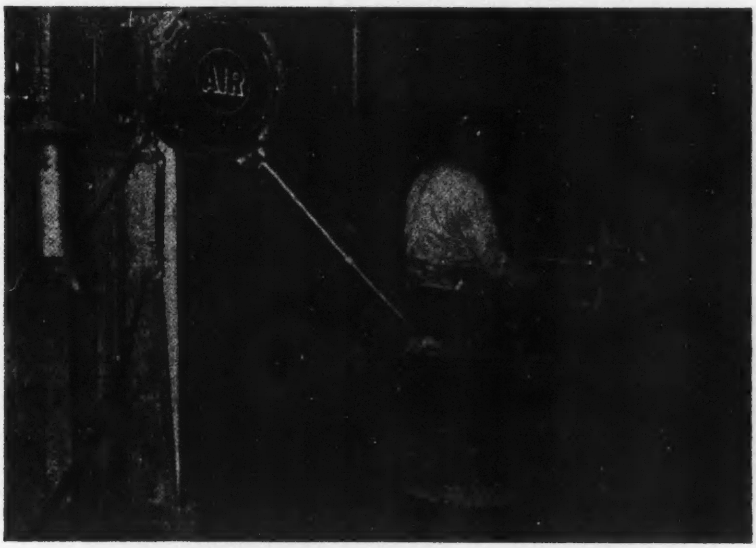
It may be concluded that whatever the SO_3 content the accuracy of the nephelometric method is identical with that of the gravimetric method, and that its regularity is at least as good, if not better. The speed at which this method can be carried out—12 to 14 minutes elapse between the initial weighing out and the result of the SO_3 content, according to whether one test or a series of tests is being carried out—makes it superior to the gravimetric method, as its flexibility does not entail a reduction of dependability. The time required for an individual test can be as little as ten minutes if the filtrate is collected in a vessel cooled in a current of cold water.

(*To be concluded.*)

Respirator for Use in Handling Bulk Cement.

THE development of a machine equipped with a scoop and driven by a petrol engine for unloading " bulk " cement from trucks has resulted in the production of a new type of respirator which gives protection against carbon-monoxide gas as well as cement dust. This is shown in the illustration.

Air is supplied to the operator from an air compressor through a hose to the mouthpiece. Between the source of the air and the mouthpiece a filter is installed to remove organic vapours and oils from the air. The amount of air supplied is controlled by a pressure-reducing valve, and a gauge is also installed to show



Air-line Respirator Used in Unloading Bulk Cement.

the operator the pressure which he is receiving so that he can adjust the amount of air to his needs. Usually the gauge is set at 10 lb. pressure which allows for sufficient air to escape on each side of the nose to keep the dust from the eyes. This type is satisfactory so far as cement dust is concerned, the hose being attached to the operator's belt, but the introduction of petrol-driven unloaders working within a truck raised a further problem.

Because the unloading machine travels back and forth at a high speed, the airline is fed from a hose-reel, so that the line is pulled from the reel when the machine moves forward and the slack is drawn back on to the reel when the machine travels back. In describing this device in "Rock Products" for July, 1945, Mr. Frank Newton says that this arrangement completely overcomes the possibility of the hose being run over by the machine or becoming an inconvenience to the operator. It was arranged to put a roller on the truck door jamb to prevent wear on the hose, but it was found that wear was so slight that a roller was unnecessary. Although the reel works perfectly, a counterweight would probably be less expensive and just as satisfactory for a temporary installation.

CEMENT AND LIME
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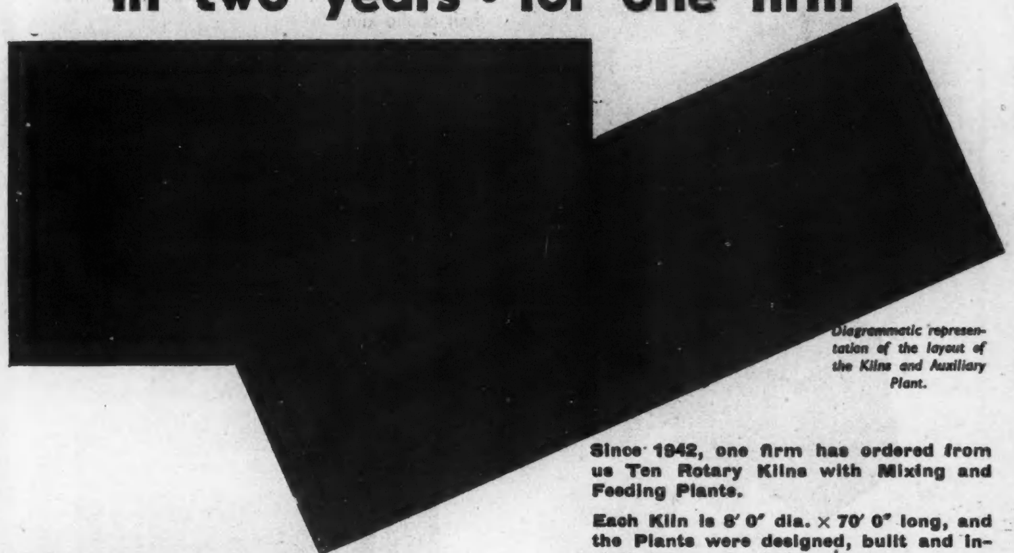

Diagrammatic representation of the layout of the Kilns and Auxiliary Plant.

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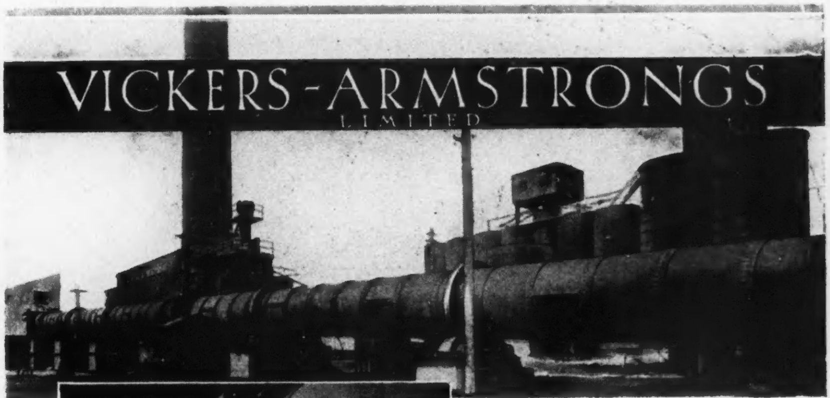
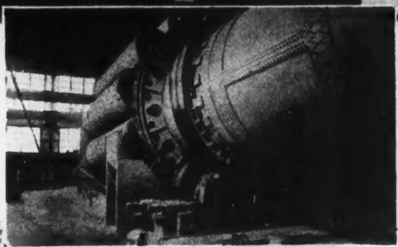
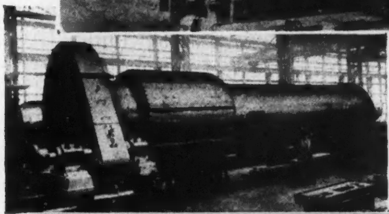




Cement Making Machinery



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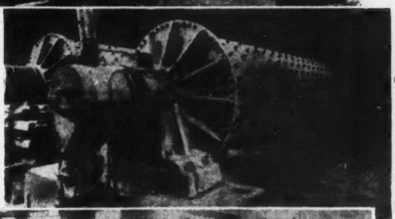

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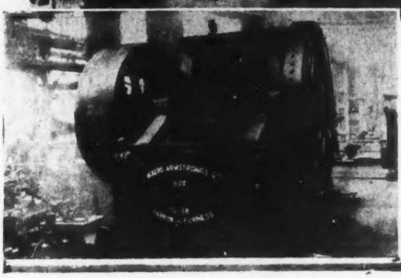

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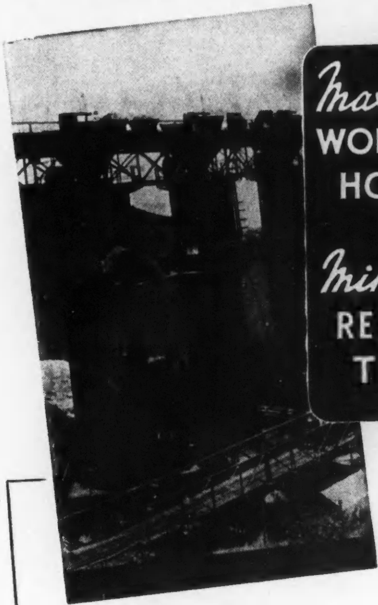
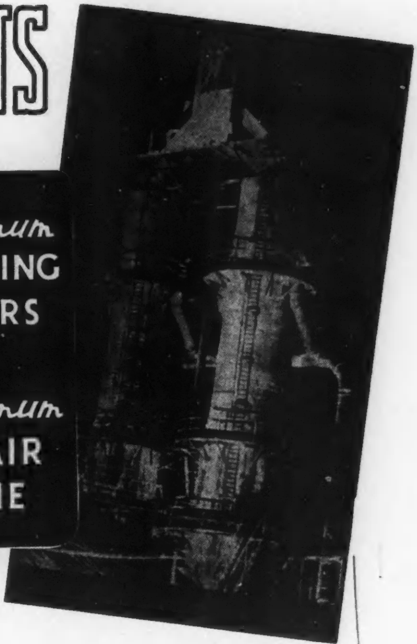


Maximum WORKING HOURS

•

Minimum REPAIR TIME



IN the National interest kilns must be kept in service for as many hours as possible. Time lost in repairs must be minimised. The reputation achieved by Davison Refractories in all parts of the world for over one hundred years guarantees their thorough dependability.

These Refractories are supplied in shapes to suit any type of construction including the Davison tongued and grooved system which adds considerably to the strength of any lining.

ADAMANTINE

Blue Adamantine blocks and bricks are hard-burnt, tough, and offer great resistance to abrasive action. They make excellent close-jointed, firm-faced brickwork which will withstand enormous pressure, and are suitable for use in the top and bottom zones.

HYSILYN

Hysilyn lime-resisting refractories, for use in the calcining zone, possess great mechanical strength in addition to the ability to withstand severe temperatures and alkaline attack. This quality is supplied with a content of alumina varied to meet the requirements of specific working conditions.

DAVISON REFRACTORIES

MADE AT THE CHARLES DAVISON BRANCH OF GENERAL REFRACTORIES LTD., GENEFAX HOUSE, SHEFFIELD, 10

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CEMENT AND LIME MANUFACTURE

Vol. XVIII. No. 2 — MARCH 1945 — Price 1/- Alternate Months

Published by Concrete Publications Ltd., 14, Dartmouth Street, London, S.W.

A

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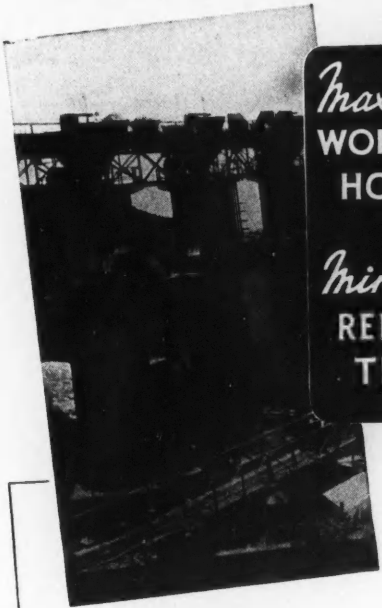

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Minimum REPAIR TIME

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Keen prices. *Send us your Enquiries.*
LINING PLATES FOR MILLS. SOUND HARD RELIABLE CASTINGS. WHITE CAST IRON. SEMI STEEL ALLOY.
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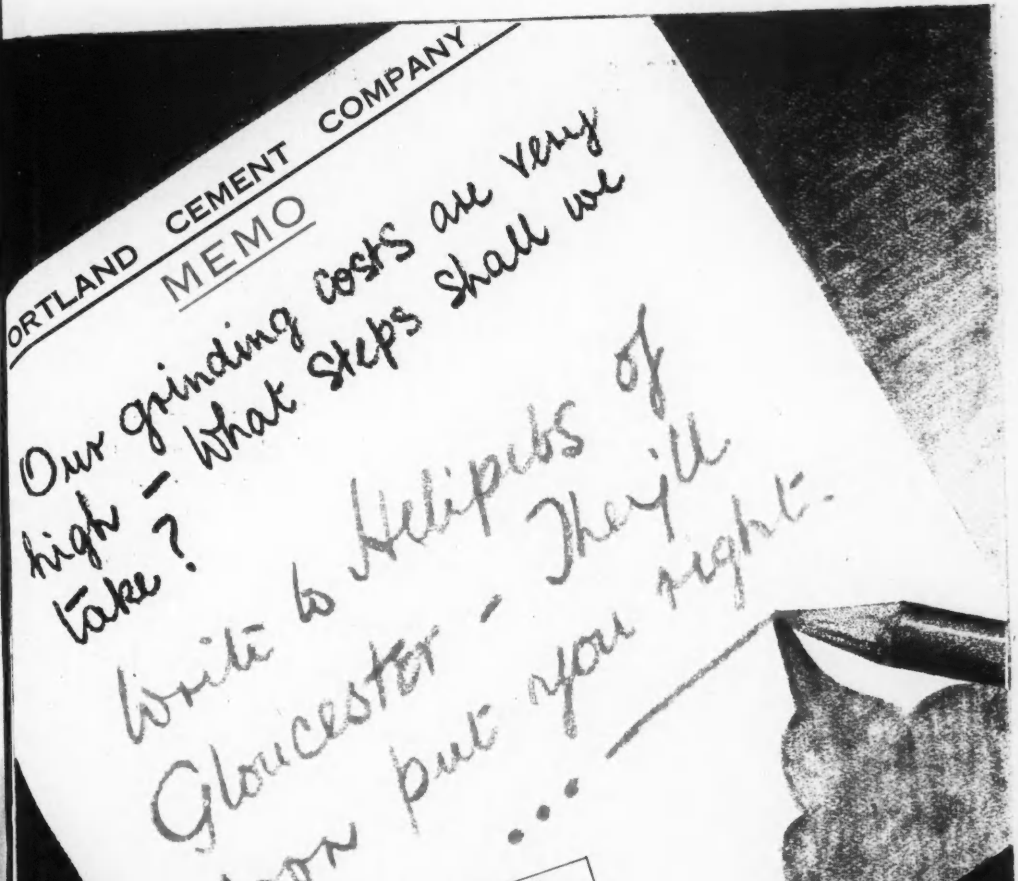
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MEMO
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Write to Helipebs of Gloucester - They'll soon put you right . . .
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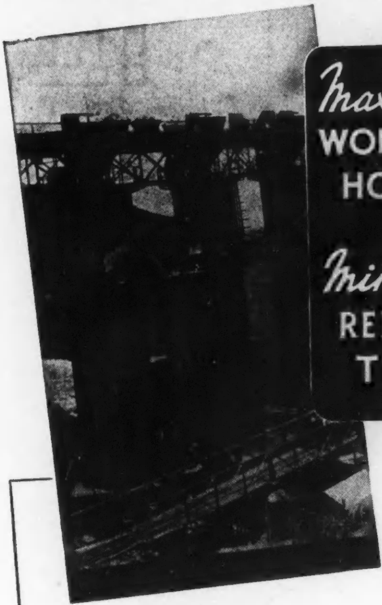
HOLPEBS, GLOUCESTER
PHONE
GLOUCESTER 4051
HELIPEBS LTD.
PREMIER WORKS, GLOUCESTER
ENGLAND.

LIME KILNS



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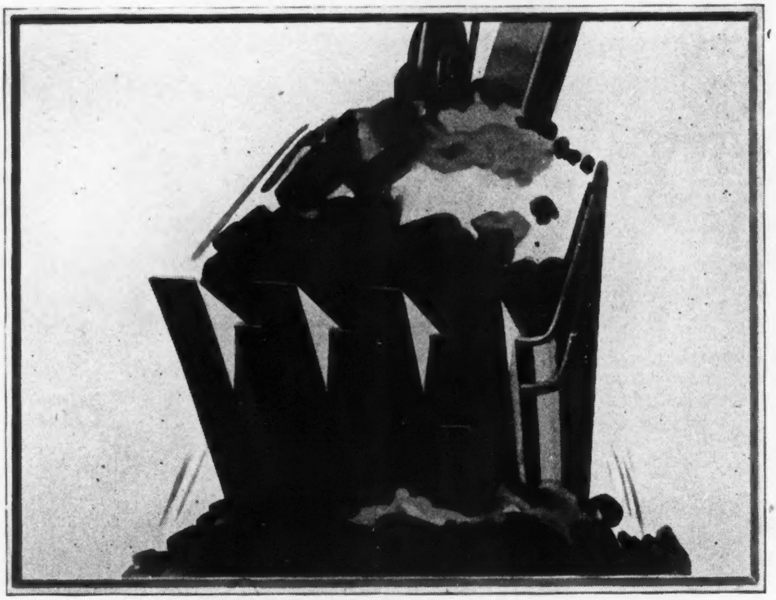

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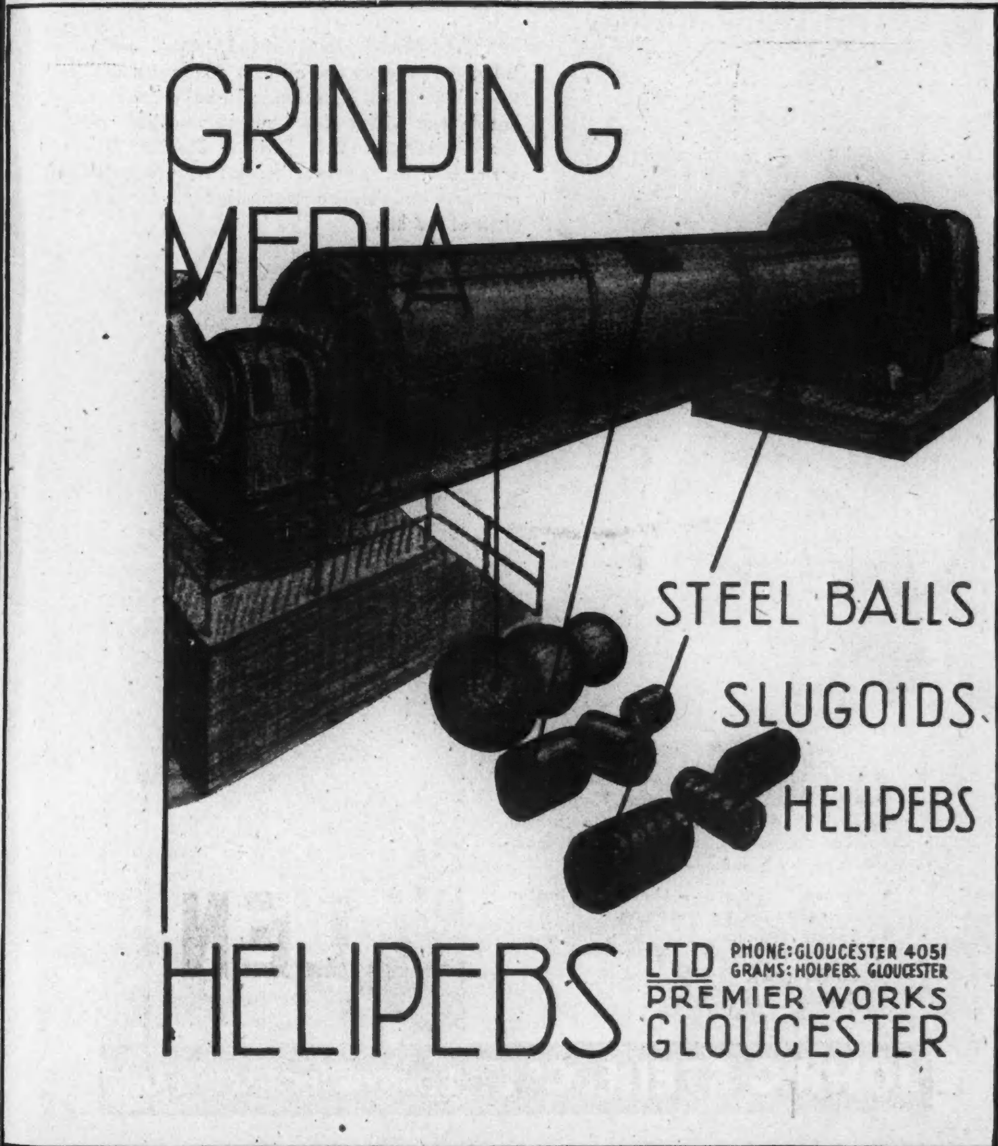
VOL. XVIII. No. 4 JULY 1945 PRICE 1/- ALTERNATE MONTHS



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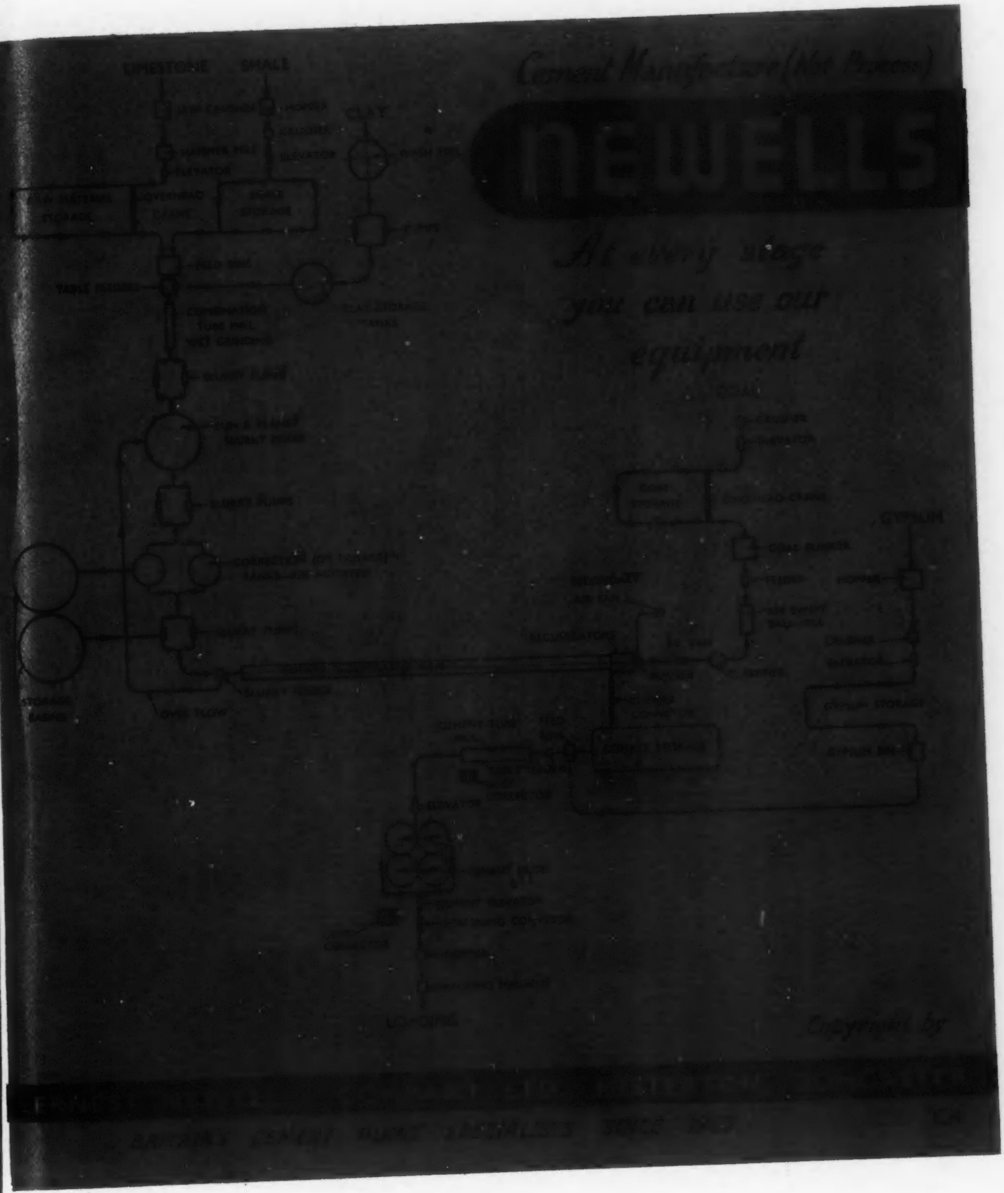
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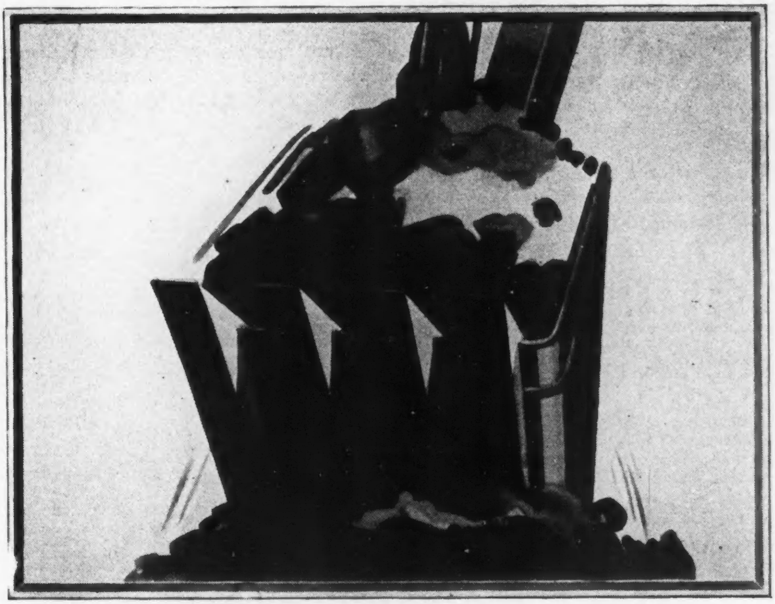

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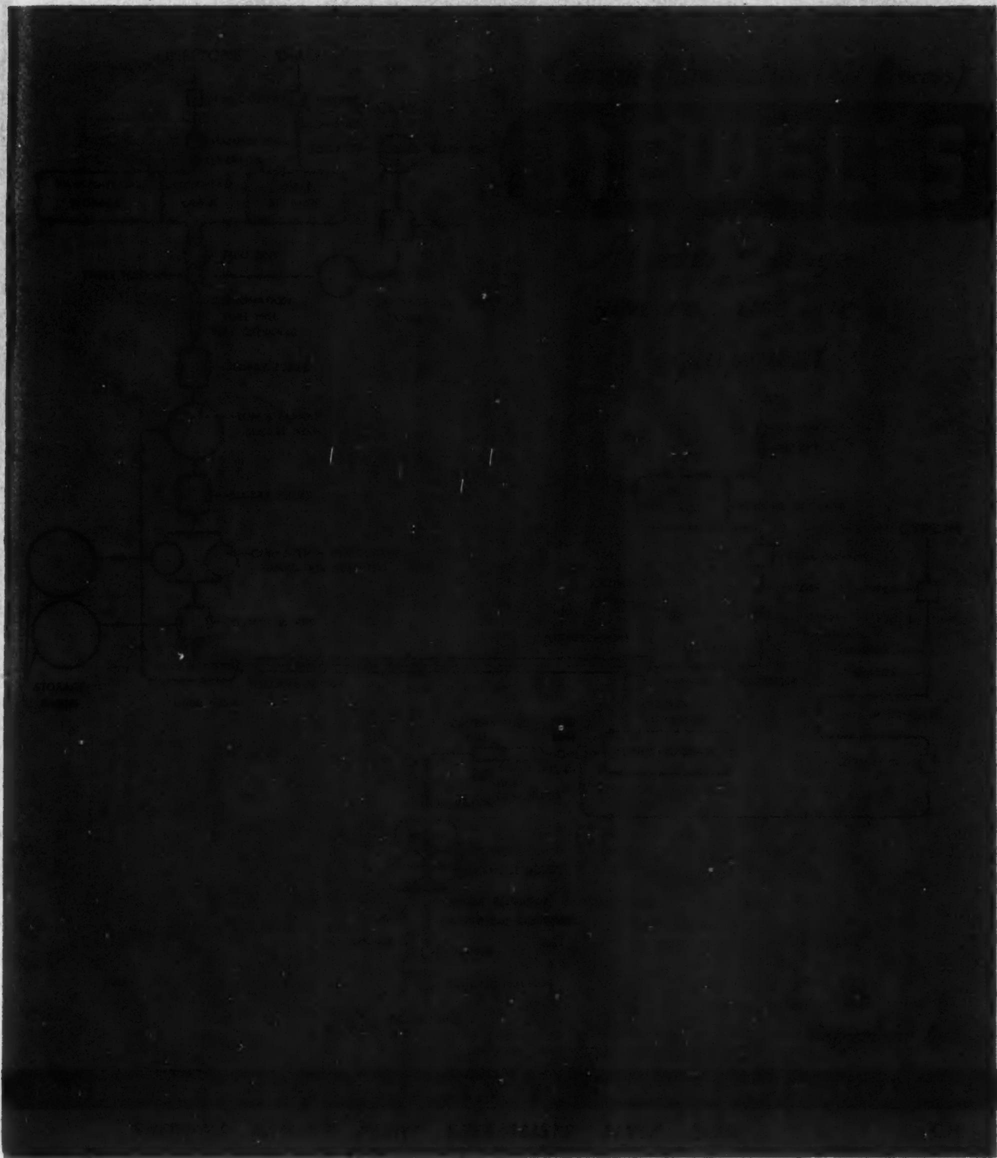
VOL. XVIII. No. 5 SEPTEMBER 1945 PRICE 1/- ALTERNATE MONTHS



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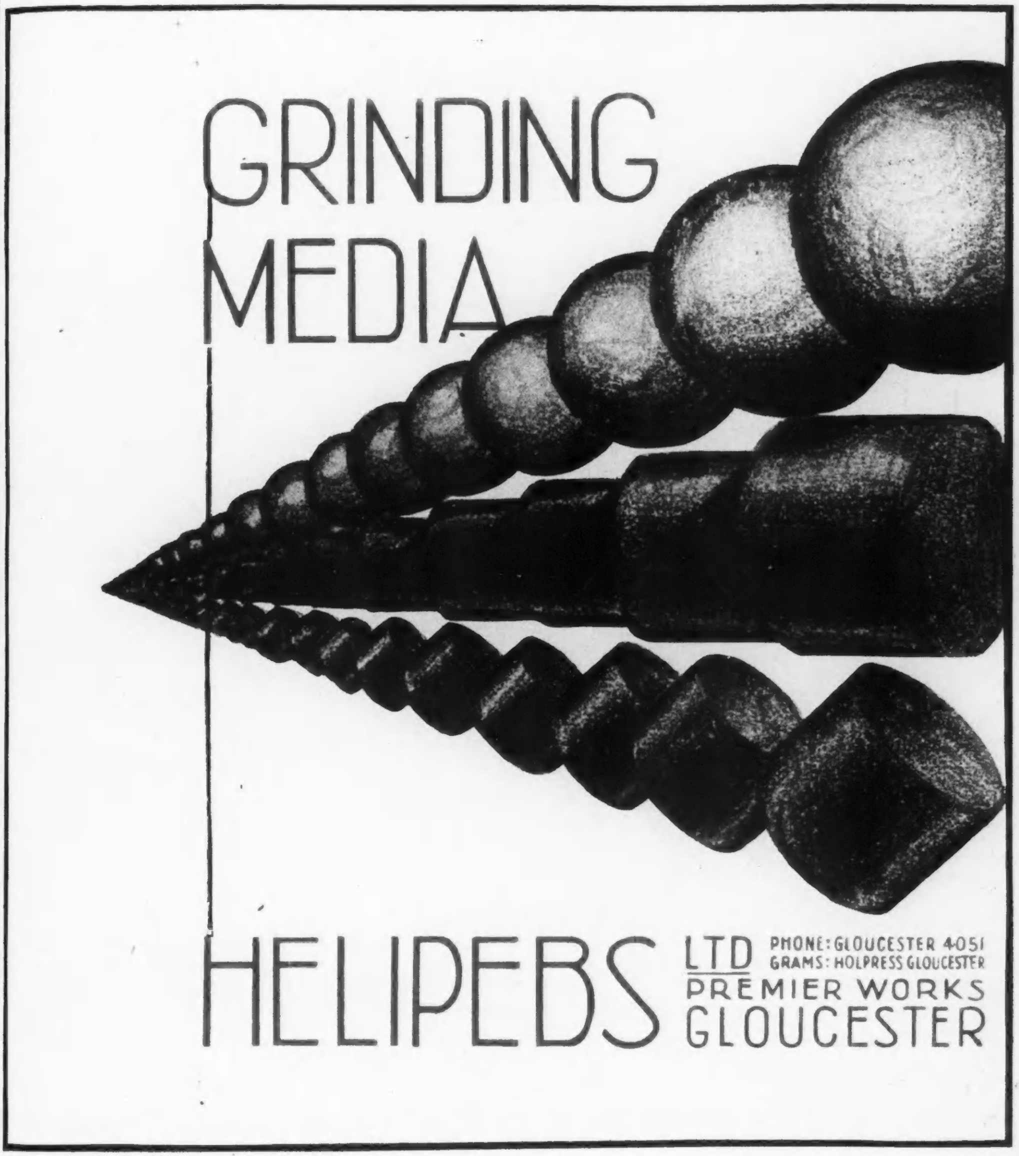
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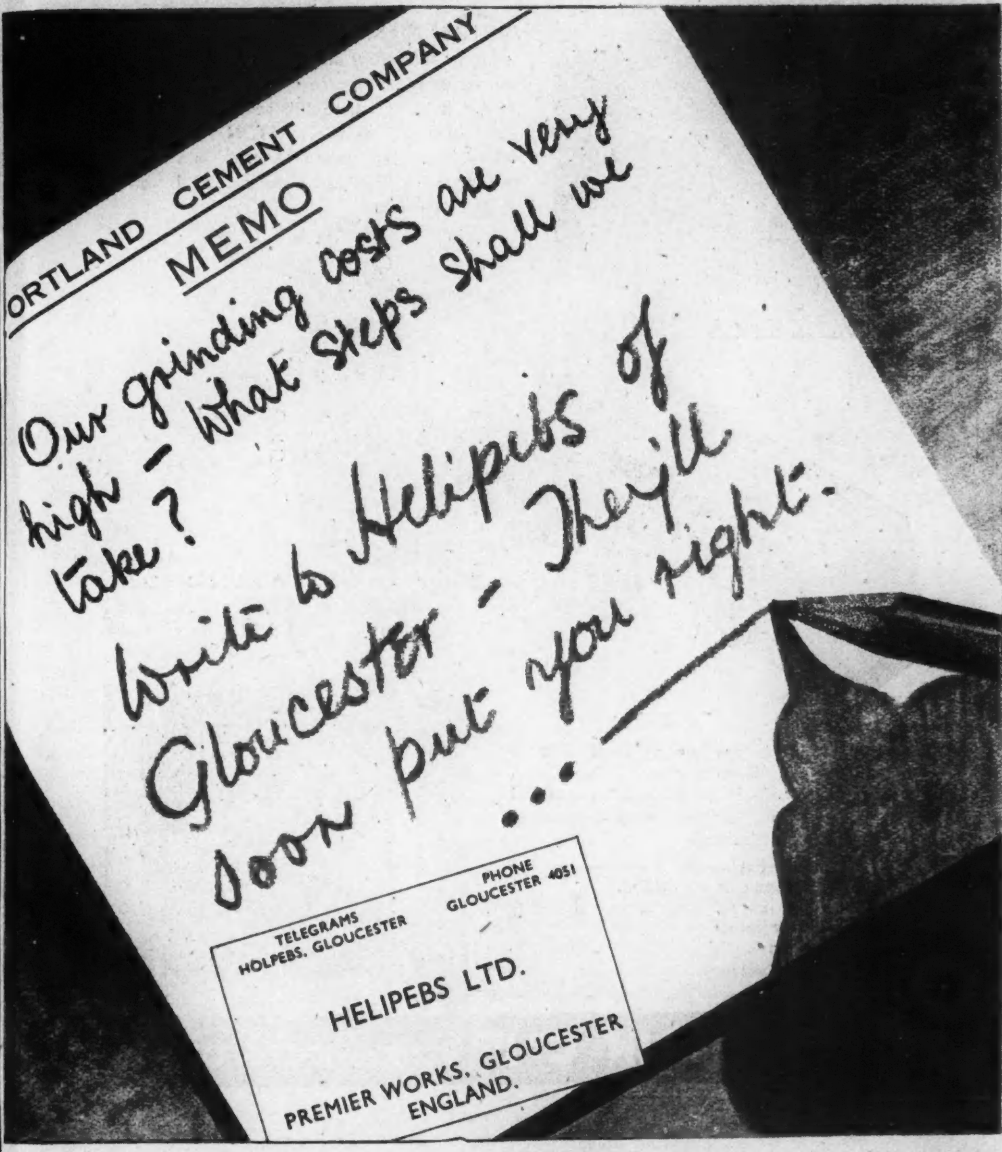
VOL. XVIII. No. 6 NOVEMBER 1945 PRICE 1/- ALTERNATE MONTHS



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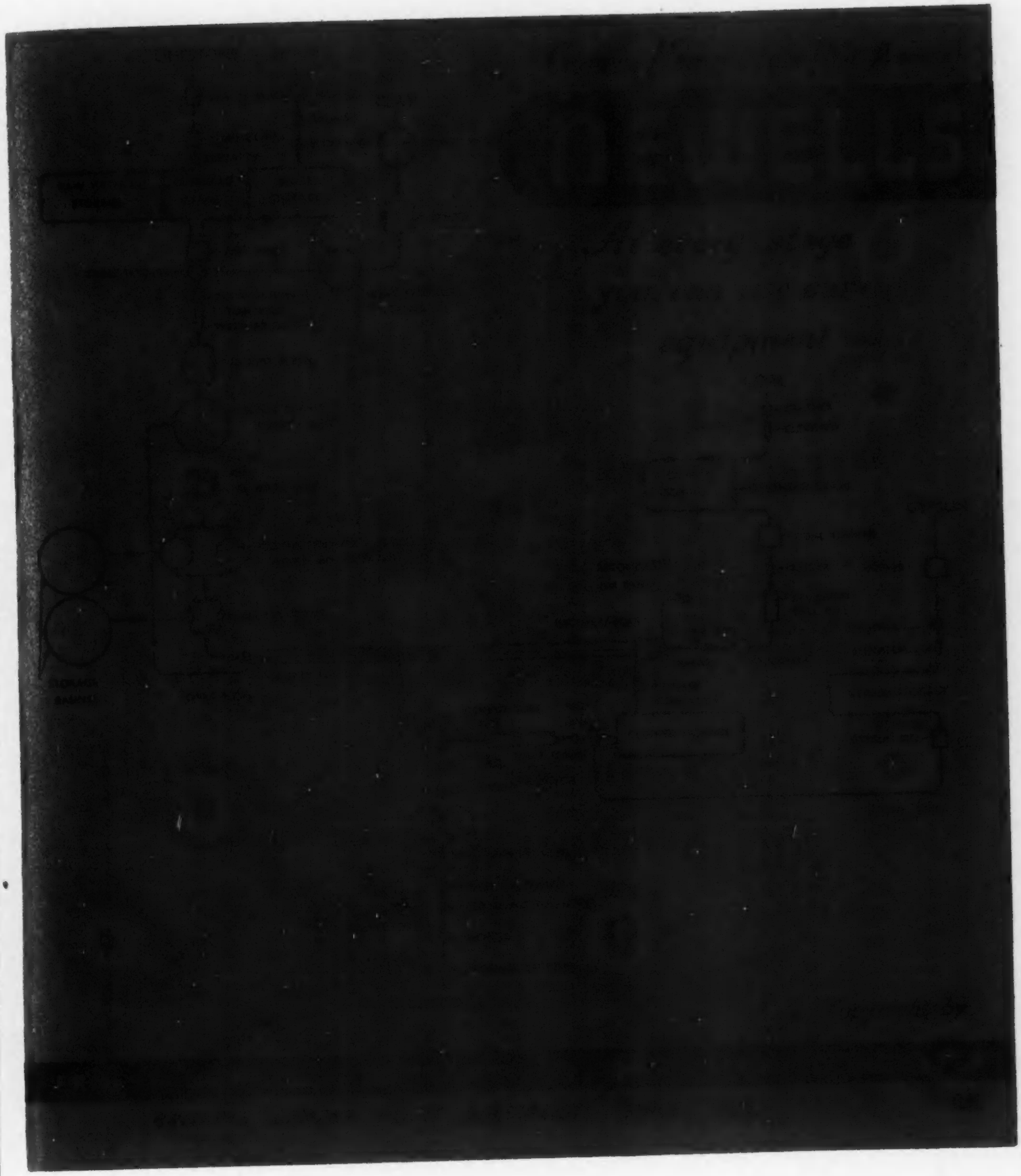

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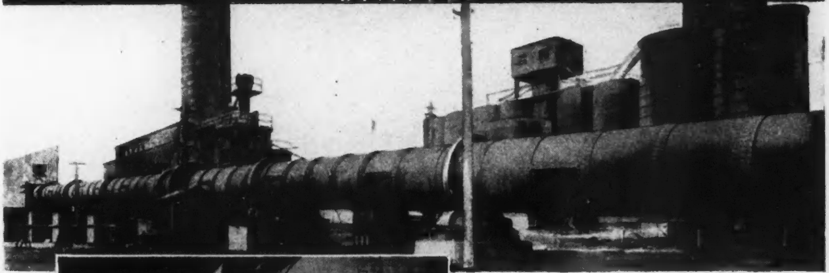
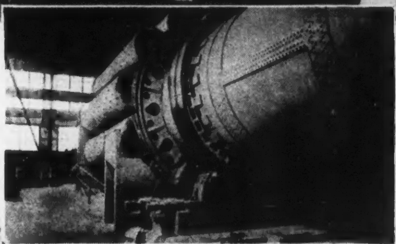
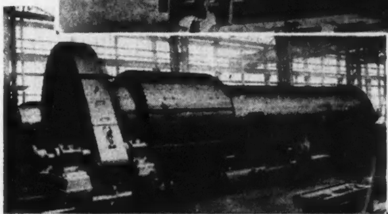
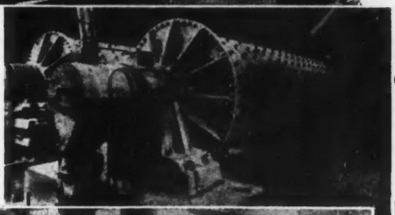
LIMITED





Cement Making Machinery





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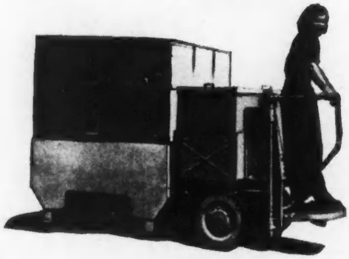
1 · 2 · 4 TONNERS



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